5. (Amended) A producing method for a silicon focus ring of a single crystal silicon used for a plasma apparatus, wherein, in order to increase an intrinsic heavy-metal gettering effect of the focus ring, a concentration of interstitial oxygen contained in the silicon focus ring is not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, the single crystal silicon is grown by a Czochralski method with doping nitrogen, a nitrogen concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, the single crystal silicon is processed in a circle, and a silicon ring is produced.

## REMARKS

Claims 1, 3 and 5 are pending. By this Amendment, claims 2, 4, 6 and 7 are cancelled without prejudice to or disclaimer of the subject matter contained therein, and claims 1 and 5 are amended. Claims 1 and 5 are amended to incorporate features from cancelled claims 2 and 6, respectively. Claims 1 and 5 are also amended to recite features supported in the specification on paragraph [0010]. No new matter is added by any of these amendments.

Applicants appreciate the courtesies extended to Applicants' representative by Examiner Anderson during the March 14, 2003 interview. The points discussed during the interview are incorporated in the remarks below and constitute Applicants' record of the interview.

Reconsideration based on the following remarks is respectfully requested.

The attached Appendix includes a marked-up copy of each rewritten claim (37 CFR §1.121(c)(1)(ii)).

### I. Claims 1, 3 and 5 Define Patentable Subject Matter

The Office Action rejects claims 1-7 under 35 U.S.C. §103(a) as being unpatentable over Ke *et al.* (U.S. Patent 6,284,093) in view of Wolf *et al.* (*Silicon Processing for the VLSI Era*, v. 1, pp. 8, 23, 27, 32-33, 59) and Tamatsuka *et al.* (U.S. Patent 6,299,982). This

rejection is rendered moot with respect to claims 2, 4, 6 and 7. This rejection is respectfully traversed with respect to claims 1, 3 and 5.

The invention of claim 1 provides a silicon focus ring for a plasma apparatus comprising silicon single crystal having a concentration of interstitial oxygen not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, and a nitrogen concentration in the silicon focus ring not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, contained therein, in order to increase an intrinsic heavy metal gettering effect of the focus ring. A silicon focus ring, as claimed, reduces impurities from heavy metals to itself and to a wafer being processed during plasma etching. Thus, the fabrication yield of semiconductor devices can be improved. See, *e.g.*, page 4, lines 2-6 and page 6, line 22 to page 7, line 3 of the specification.

The invention of claim 5 provides a method for producing a silicon focus ring, grown by a Czochralski method into a single crystal having a concentration of interstitial oxygen not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, and a nitrogen concentration in the silicon focus ring not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, contained therein, in order to increase an intrinsic heavy metal gettering effect of the focus ring. The method, as claimed, yields a silicon focus ring having sufficient gettering effect to improve focus ring longevity. The resulting silicon focus ring with specified interstitial oxygen therein thus reduces heavy metal impurities from plasma etching of a wafer.

As discussed above, the independent claims recite features including a silicon focus ring doped with nitrogen so that the a concentration of interstitial oxygen not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, and a nitrogen concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$. Accordingly, the claimed features produce a higher gettering effect for the silicon focus ring

than otherwise available. Thus, the disadvantages of impurities from heavy metal can be prevented, thereby improving the yield in semiconductor device fabrication. See, *e.g.*, page 6, line 21 - page 7, line 3 of the specification.

In particular, because the silicon focus ring is doped with nitrogen at a concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, oxygen precipitation in a bulk portion of the silicon focus ring is promoted sufficiently so that the gettering effect can e more effective. See, *e.g.*, page 5, lines 13-17 of the specification.

By contrast, the January 30, 2002 and June 12, 2002 Office Actions assert that Ke describes a silicon focus ring, Wolf teaches that oxygen doping increases the strength of a silicon wafer, and that Tamatsuka discloses the oxygen concentration of the present invention. Thus, the Office Actions allege, that those of ordinary skill in the art could expect that the life of the silicon focus ring would be extended by the increased material strength imparted to the silicon by the presence of oxygen in the concentrations of the recited features. See, *e.g.*, page 5, line 2 from the bottom - page 6, line 9 in the June 12, 2002 Office Action.

On the contrary, in response to the December 2, 2002 Office Action, Applicant asserts that because Ke states that a focus ring preferably is composed of pure silicon, that Ke teaches away from the recited features of Applicants' claims. Even if Wolf or Tamatsuka describes a wafer doped with oxygen, one of ordinary skill in the art would not expect to combine these teachings with Ke. Any such combination among the cited references would not produce the particular advantages provided in Applicants' claims.

The December 11, 2002 Advisory Action and the December 19, 2002 Office Action assert the following:

(1) Ke teaches that oxygen released from silicon oxide leads to damaging effects, but Ke does not make an issue of oxygen impurity contained in silicon. Oxygen impurities in

the silicon is small compared to the oxygen released from silicon oxide. Hence, the Office Action asserts that the argument that Ke teaches away from the present invention is not persuasive.

(2) Czochralski silicon inherently has oxygen concentration of the present claims and Tamatsuka describes the oxygen concentration of the present claims. This oxygen concentration is a common oxygen concentration in the Czochralski method.

(3) Because Ke describes improvement of the life of the silicon focus ring and Wolf describes mechanical strength being increased by nitrogen or oxygen doping, the Office Action asserts that it would have been obvious to one of ordinary skill in the art to combine Ke and Wolf to improve the life of the focus ring, irrespective of other advantages derived, thereby precluding allowance of the claims. See, *e.g.*, col. 6, lines 30-50 of Ke and page 32 of Wolf.

However, Applicants traverse these assertions. With respect to assertion (1), Ke describes the damaging effect of oxygen released from a quartz ring of silicon oxide in col. 8, lines 39-50. bit that it can be readily obtained in forms having extremely low impurity concentrations so as to avoid the release of contaminants into the chamber in col. 6, lines 34-37. Further, Ke describes that single crystal silicon is preferred because it can be obtained with the highest purity. See, *e.g.*, col. 6, lines 37-38 of Ke.

Thus, Ke makes an issue not only of oxygen released from silicon oxide but also impurities contained in silicon because the chamber is contaminated with impurities. Therefore, the argument that Ke teaches away from the present invention should be persuasive. Even if the amount of oxygen impurity contained in silicon is smaller than that of oxygen released from silicon oxide, one of ordinary skill in the art would not thereby conclude that a silicon focus ring, as disclosed in Ke, is doped with impurities.

With respect to assertion (2), the focus ring as recited in Applicants' claims is doped with nitrogen of which concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$. Nitrogen of such a concentration cannot be doped without the precise control of nitrogen concentration in the Czochralski method. See, *e.g.*, page 11, line 11 - page 12, line 4 of the specification. Therefore, a common silicon item does not exhibit the above nitrogen concentration. Accordingly, Applicants' claimed features are not easily derived by one of ordinary skill in the art.

With respect to assertion (3), Ke improves the life of a focus ring by increasing erosion resistance thereof. See, *e.g.*, col. 6, lines 33, 40-42, 48-49 and 53 of Ke. However, there is no teaching or suggestion that the life of a focus ring is improved by improvement of its mechanical strength.

On the contrary, Wolf describes that the mechanical strength is increased by nitrogen or oxygen doping, but neither teaches nor suggests improvement of erosion resistance. Further, the mechanical strength of Wolf relates to increasing the warpage resistance of a wafer that requires precise flatness for fabrication of devices on its surface. See, *e.g.*, page 32, line 3 from the bottom of Wolf. The focus ring of Applicants' claims does not pertain to fabrication of devices on its surface. Therefore, Wolf does not relate to the focus ring having Applicants' claimed features.

Although Tamatsuka describes a specific nitrogen concentration, that concentration is used to eliminate crystal defects in a wafer for fabrication of a device to which precise electrical properties are fundamental. See, *e.g.*, col. 1, line 65 - col. 2, line 2 of Tamatsuka. Thus, Tamatsuka does not relate to the focus ring of Applicants claimed features, and therefore one of ordinary skill in the art would not apply the nitrogen concentration of Tamatsuka for device fabrication on a wafer to a non-analogous focus ring.

The December 19, 2002 Office Action, at page 6, asserts that Tamatsuka, combined with Ke, suggests using the silicon wafer for producing a ring to one of ordinary skill, because such construction would require only simple milling to form a hole. However, for the environment and required performance, a focus ring of high purity and erosion resistance in a plasma apparatus differs markedly from a wafer requiring warpage resistance for installing devices thereon. Therefore, one of ordinary skill in the art would not apply the impurity concentration of a wafer as it would be to the focus ring of Applicants' claims.

In addition, Ke teaches away from Applicants' claimed features that the focus ring is doped with impurities, so that even if Wolf or Tamatsuka describes that a wafer is doped with oxygen or nitrogen, one of ordinary skill in the art would not combine Ke with Wolf and Tamatsuka. Hence, Applicants' claims cannot be derived from the combination.

Rather, in Applicants' features, the nitrogen having a concentration in the silicon focus ring not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, is used to increase gettering effect in the silicon focus ring and thereby prevent particles from contaminating the plasma chamber. Further, this nitrogen concentration can be derived only through experiments and investigations about the relation between nitrogen concentration and gettering effect in the silicon focus ring. See, *e.g.*, page 9, line 14 - page 10, line 9 of the specification. By contrast, none of the applied references recognizes a gettering effect by nitrogen doping, and thus there is no motivation to combine and thereby derive Applicants' claimed features by combining Ke, Wolf and Tamatsuka.

As described above, Applicants' claimed features cannot be derived from the combination of the applied references. Further, Applicants' claimed features produce sufficient gettering effect for the silicon focus ring so that impurities such as heavy metal on a silicon wafer can be prevented. See, *e.g.*, page 7, lines 15-24 and page 14, lines 1-11 of the specification.

None of the applied references (Ke, Wolf and Tamatsuka) recognizes or addresses the combination of the claimed features. Thus, the applied references fail to disclose or provide motivation for combining their teachings for achieving Applicants' claimed features. The functional and fabrication distinctions between a focus ring of silicon and a nitrogen doped wafer demonstrate a lack of motivation to combine the structure and method disclosed in Ke with the methods described in Wolf and Tamatsuka.

Because Ke, Wolf and Tamatsuka have no relation to each other in context to a nitrogen doped silicon focus ring as claimed, there is no motivation to combine these references. Even assuming motivation could be found, the combination of Ke, Wolf and Tamatsuka does not teach or suggest a silicon focus ring having a nitrogen concentration in the silicon focus ring of not less than $5\times10^{13}$ number/$cm^3$ and not more than $5\times10^{15}$ number/$cm^3$.

Based on the above arguments, independent claims 1 and 5 of the present invention cannot be properly rejected under 35 U.S.C. §103, and therefore are now in condition for allowance. Additionally, claim 3 depending from claim 1 should be allowed by the same reasons above plus for the additional features it recites. Accordingly, Applicants respectfully request withdrawal of the rejections of claims 1, 3 and 5.

For at least these reasons, Applicants respectfully assert that the independent claims are now patentable over the applied references. The dependent claim is likewise patentable over the applied references for at least the reasons discussed as well as for the additional features recited. Consequently, all the claims are in condition for allowance. Thus, Applicants respectfully request that the rejections under 35 U.S.C. §103 be withdrawn.

## II. Conclusion

In view of the foregoing amendments and remarks, Applicants respectfully submit that this application is in condition for allowance. Favorable reconsideration and prompt allowance are earnestly solicited.

Should the Examiner believe that anything further is desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned representative at the telephone number listed below.

Respectfully submitted,

William P. Berridge
Registration No. 30,024

Gerhard W. Thielman
Registration No. 43,186

WPB:GWT/gwt

Attachment:
Appendix

Date: March 19, 2003

**OLIFF & BERRIDGE, PLC**
**P.O. Box 19928**
**Alexandria, Virginia 22320**
**Telephone: (703) 836-6400**

DEPOSIT ACCOUNT USE AUTHORIZATION
Please grant any extension necessary for entry;
Charge any fee due to our Deposit Account No. 15-0461

APPENDIX

Changes to Claims:

Claims 2, 4, 6 and 7 are canceled.

The following is a marked-up version of the amended claims:

1. (Amended) A silicon focus ring ~~consisting of~~ comprising silicon single crystal used as a focus ring in a plasma apparatus, wherein, in order to increase an intrinsic heavy metal gettering effect of the focus ring, a concentration of interstitial oxygen contained in the silicon focus ring is not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, and a nitrogen concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$.

5. (Amended) A producing method for a silicon focus ring of a single crystal silicon used for a plasma apparatus, wherein, in order to increase an intrinsic heavy-metal gettering effect of the focus ring, a ~~single crystal silicon wherein~~ concentration of interstitial oxygen contained in the silicon focus ring is not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, the single crystal silicon is grown by a Czochralski method with doping nitrogen, a nitrogen concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, the single crystal silicon is processed in a circle, and a silicon ring is produced.

Docket No. 107703

Application No. 09/696,955

APPENDIX

PROPOSED

Changes to Claims:

Claims 2, 4, 6 and 7 are canceled.

The following is a marked-up version of the amended claims:

1. (Amended) A silicon focus ring ~~consisting of~~ comprising silicon single crystal used as a focus ring in a plasma apparatus, wherein a concentration of interstitial oxygen contained in the silicon focus ring is not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, and a nitrogen concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$.

5. (Amended) A producing method for a silicon focus ring of a single crystal silicon used for a plasma apparatus, wherein a ~~single crystal silicon wherein~~ concentration of interstitial oxygen contained in the silicon focus ring is not less than $5\times10^{17}$ atoms/cm$^3$ and not more than $1.5\times10^{18}$ atoms/cm$^3$, the single crystal silicon is grown by a Czochralski method with doping nitrogen, a nitrogen concentration in the silicon focus ring is not less than $5\times10^{13}$ number/cm$^3$ and not more than $5\times10^{15}$ number/cm$^3$, the single crystal silicon is processed in a circle, and a silicon ring is produced.

PROPOSED